

Annex 7 - Water Supply, Sanitation and Solid Waste Management Sectors

I. Introduction

1. Impacts resulting from the absence of basic infrastructure and environmental services in the atolls have been further exacerbated by the damage that followed the high waves and flooding of the Indian Ocean tsunami which hit the Maldives on 26 December 2004, leading in some cases to absolute destruction of existing infrastructure. The sector has been seriously affected: whilst provision of water supply and basic sanitation services are in urgent need of reconstruction and/or development, the need to expedite adequate solid waste management practices and structuring the sector for efficient operation have emerged to be critical at this stage.

II. Government's Immediate Response

2. Following the immediate creation of a task force for emergency relief on 26 December 2004 and the specific establishment of a water and sanitation work group coordinated by the Medical Relief Unit at the National Disaster Management Center (NDMC), water and sanitation emergency requirements for the Maldives were identified to support approximately 2,200 affected households (equivalent to an estimated population of 15,000) in 69 islands, of which 36 highly or very highly affected islands are to be prioritized. However, the exact number of affected households and the level of damages to the water and sanitation facilities have not been identified. Basic drinking and cooking water supplies are in the process of being distributed in the form of packaged water (30,000 liters) and 20 small reverse osmosis (and associated generators) desalination units. In addition, water disinfectant tablets, detergent tablets (10,000), ground bladder PVC tanks (5-10 m³) for water storage, water-testing kits and laboratory equipment (for residual chlorine content and total fecal coliforms testing), household HDPE (2.5 m³), as well as dustbins (15,000 pieces being proposed) are in the process of being acquired and delivered. Transportation, boat availability and coordination logistics have proven to be a key in the delivery of goods and services.

3. The communities in the islands have mobilized, in many cases initiating the removal of solid waste and debris from water wells, clearing and concentrating construction debris in peripheral areas. Where possible, communities have organized sharing the provision of overall drinking and cooking water supplies, undertaking activities communally (such as cooking), as well as sharing sanitation facilities and shelter, where housing and services remain standing and functioning.

4. UNICEF, various bilateral donors such as German THW, NGOs such as Oxfam, and local private parties have actively participated in the delivery of water supplies and services and other basic necessities to hundred of families throughout the country. Several of these also plan to continue supporting rehabilitation and reconstruction programs, therefore close donor coordination will be required.

III. Methodology of Damage and Needs Assessment

5. **Methodology.** Damage and needs evaluation considers asset losses and acceptable replacement alternatives. This assessment is based on data and information provided by the Government (data management center) and supplemented by data and analyses obtained from a variety of existing reports prepared under the supervision of various Government agencies over the past 5 years, as well as field visits. A precise assessment of the damage is not possible at this stage, due to the wide spatial spread of damage, the relatively short period following the disaster and data logistics. The data available to the mission was limited and in order to strengthen sector findings, a questionnaire on water supply and sanitation was prepared and conveyed to the atoll and island offices for immediate completion and return to NDMC. Time and response restrictions have only permitted to use some of this data for extrapolation

and generation of projections. On receipt of all information from this survey, a more detailed assessment could be completed. The needs assessment has focused in identifying adequate solutions for the 69 most affected islands.

6. **Consultations and Site Visits.** GOM is conducting a series of engineering and technical site visits in order to more accurately establish reconstruction needs. The task force has provided the mission with a set of reports, covering a number of islands, which contain damage estimates for different sectors including housing. Additional reports have been prepared by a series of donor agencies, including the International Red Cross and Red Crescent Federation and AUSAID, all of which have been considered in this assessment. Moreover, the mission visited Kholufushi and Naalaafushi Islands in Meemu atoll, one of the most affected, on 11 January 2005 in order to collect information on the extent and nature of damages in the island, for possible extrapolation to other centers. The needs assessment is in line with Government's policy, which was confirmed through meetings with the Ministry of Finance and Treasury (MOFT), Ministry of Planning and Development (MPND), the Maldives Water and Sanitation Authority (MWSA), The Maldives Housing and Urban Development Board (MHUDB), Ministry of Environment and Construction (MEC) and the Ministry of Atolls Development (MOAD).

IV. Damage Assessment

7. **Water Supply.** Water supply in the atolls is almost entirely provided through a combination of rainwater tanks (both household and communal), which are the principal source of drinking water and groundwater extraction, mainly through domestic wells. Prior to December 2004, Malé, R. Kadholhudhoo and Kommandhoo (28% of the total population) were the sole inhabited islands with access to desalinated water. For a number of years, population and development pressures have led to increasing groundwater extraction, resulting in the depletion of the freshwater lens, which in turn, has led to saline intrusion into the ground aquifer. Groundwater resources have also been at risk of bacterial contamination caused by effluent leakage and pollutant migration from poorly constructed and maintained septic tanks.¹

8. The tsunami event further aggravated the limited freshwater resource available to the country. The freshwater lens has been significantly affected throughout the country and the duration and the reversibility of this impact is uncertain.² As a result, tested wells have shown unusually high conductivity and saline levels, particularly in those islands completely flooded and classified by GOM as suffering of "high" or "very high" impact. Monitoring of the saline content of the convex lens-shaped body of freshwater positioned above seawater and its transition zone over the next few months will allow for a more accurate evaluation. In addition, poor construction and tsunami wave-damage to septic tanks and other sewage systems have resulted in pollutant migration and sewage contamination of groundwater sources.³ Groundwater, commonly utilized for washing and bathing, has been reported not to be adequate for use in 48 islands, although this situation may change with cleaning of wells and chlorination.

9. Drinking and cooking water, harvested only in household and communal water tanks has been estimated to be totally lost in the 69 most affected islands, adding up to a potential estimated amount of 13,000m³, which could be as high as 20,000 m³ for the entire country. This is a particularly important loss at the beginning of the dry season, when water-harvesting rates are at their lowest. Five hundred rainwater tanks, amounting to a total of 800,000L, have been reported lost or damaged by the islands offices. However, it has also been observed that many islands significantly affected have not yet reported their

¹ *State of the Environment, Maldives 2004*, reported groundwater resources in 54% of islands not to be suitable for drinking due to salt water intrusion and 46% of islands where groundwater was not suitable due to pollution (Ministry of Environment and Construction. 2004. *State of Environment, 2004*. Maldives).

² Hydrological and conductivity testing should be undertaken as a function of precipitation to monitor the evolution of freshwater lens recovery.

³ Bacteriological testing undertaken by UNICEF and MWSA displays positive values for *E-Coli*.

losses, and based on atoll data extrapolations, the number is estimated to be substantially larger adding to as many as 1000 community rainwater tanks and 6000 household rainwater tanks. Roof water harvesting piping and gutter systems are also expected to be damaged affecting an estimated 5000 households. Eight hundred and fifty well-pumps are estimated to have been lost as a result of flooding. No damage has been reported to existing reverse osmosis facilities serving the Maldives prior to the tsunami disaster. Overall damage due to loss of assets in the water supply sector is estimated to be MRf 65 million (\$ 5.1 million).

10. **Sanitation.** Sanitation in most islands is effected partly by pour-flush latrines connected to a sewage system, or to a much lesser extent, by use of holes in backyards. In high-density island environments, the construction and operation and maintenance of septic tanks is complex, and often suffers from poor performance due to a variety of reasons which include absence or limited desludging. Small-bore systems are a common alternative but they are generally not well designed, often malfunction, and usually convey raw sewage directly into the lagoon. Assets rapidly deteriorate due to deferred maintenance and faulty systems are conducive to marine pollution. Furthermore, a large number of septic tanks are solely associated to a soak-pit, from which sewage can freely migrate through the highly porous island soil, contaminating groundwater sources. Remaining septic tank systems are connected to sewerage systems with a sea outfall. Sewage treatment systems in the Maldives are scarce.

11. The extent of damage to the sanitation and sewerage network is still uncertain. Estimates regarding the number of toilets which may have been potentially lost has been directly correlated to the number of houses in need of repair or reconstruction and estimated to be as large as 5000 units. In extensively affected areas, where entire islands have been subjected to flooding for an extended period of time and delayed flood water retreat periods, septic tanks may need replacing, or when the structures remain undamaged, desludging will be required to ensure desalination and adequate bacterial anaerobic digestion conditions. The number of septic tanks and associated connections lost to the tsunami is estimated to be 1,500 units, whilst small bore sewer and outfall loss in highly affected areas needing replacement could be as high as 126 km and 2.4 km of outfall. Whilst Malé is not served by a needed sewage treatment system, Kuldhufushi pilot semi-mechanical aerobic sewage treatment plant, and MWSA reed bed piloting facilities have not yet reported any specific damages to their infrastructure. Overall damage to sanitation infrastructure loss (in the form of latrines, septic tank and sewerage networks and sea outfall damages) has been estimated to be MRf 72.4 million (\$ 5.6 million).

12. **Solid Waste Management.** Solid and hazardous waste management has emerged to be one of the greatest challenges in the Maldives. Whilst, the central landfill facility of Thilafushi⁴ serves Malé, Vilingili, Hulhumale, resorts and industrial islands, no formal waste management systems exist in the atolls, with the exception of Kuldhufushi and Hithadhoo landfill sites. While no loss of assets or damages have been reported at this stage in either the atolls nor the Thilafushi center, the potential environmental impact which might have resulted from the discharge of hazardous waste from Thilafushi island into the Ocean needs to be reviewed, as part of a strategy leading to the construction of a safe and environmentally acceptable solid waste management center for the country's capital. Visits to both North and South Regional Development Management Centers are required to confirm absence of damages to soil or facilities, particularly to Kuldhufushi, where damages were reported to be substantial, as it is uncertain whether the design of these centers could accommodate tsunami resulting debris. Since no lining had yet been made available to either center, no damage is associated with it, however it remains much needed. More importantly, the need to expedite adequate solid waste management practices in the atolls and structuring the sector for efficient operation has emerged to be critical in order to rapidly cope with the collection and disposal of debris resulting from tsunami damage and destruction. Overall damage

⁴ According to the State of Environment report, more than 103,000 tons of waste is transported yearly from Malé to Thilafushi (Ministry of Environment and Construction. 2004. *State of Environment, 2004*. Maldives).

to waste disposal systems, specifically relating to medical waste and damage and loss of hospital incinerators is estimated to be MRf 1 million (US\$ 0.08 million).

V. Needs Assessment

13. **Immediate and Short Term Needs (3–6 months).** Immediate and short term efforts should focus on (i) the provision of immediate safe water to affected areas, (ii) provision of basic temporary sanitation facilities and rehabilitation of existing sanitation infrastructure, (iii) initiating a solid waste management program for clearing and recovery of debris material, as well as (iv) attending to immediate community awareness and capacity building required to undertake the above tasks.

14. Short-term needs in the water supply and sanitation sector should focus primarily on immediately providing:

- (i) safe drinking and cooking water supplies, initially (dry season) in the form of small mobile desalination systems (46 units) and/or bottled water (more costly and with higher associated logistic and transportation requirements), soon after to be followed by the repairing and provision of new household and communal (schools, hospitals, mosques and communal areas) rainwater tanks (1000 community rainwater tanks and 6650 household rainwater tanks replacing units lost as well as providing clean water to individuals previously depending on groundwater sources for drinking and cooking) and rehabilitation of associated roof rainwater harvesting piping and gutters, for immediate replenishment at the end of the dry season, fulfilling drinking and cooking water requirements. This should be complemented with the supply disinfectants and water chlorination tablets, where water from wells or water sources otherwise considered unsafe, are to be used.
- (ii) temporary sanitary latrines⁵ (1800 units) to communities in high or very high impact areas, where toilets have been destroyed or reconstruction and rehabilitation of septic tanks prevents the utilization of such facilities. This should be coupled with the acquisition of septic tank desludging systems (34 units) and adequate impermeable lining for the construction of temporary sludge drying beds;

15. Immediate actions to be undertaken in the solid waste management sector should focus on providing:

- (iii) a solid waste management program, focusing on waste segregation and material reuse/recycling, particularly in those islands most affected by the destructive tsunami wave⁶. The program will emphasize waste segregation into biodegradables for composting, recyclables for further re-use and sale for recycling, and non- recyclables (including hazardous) for safe disposal in centralized facilities. The program should include the purchase of communal wheeled and/or household bins for the 48 reported most affected islands, and equipment allowing for both the separation of wastes and its safe and effective processing and removal from the islands. In order to achieve a cost efficient system, which could be financially sustainable in the medium term, the program requires to consider atoll-level coverage. Selected equipment shall include amongst other shredders, glass crushers and composting bins (48 systems);⁷

⁵ Community acceptance of these units needs to be confirmed, else cultural sensitization/awareness could be raised.

⁶ The tsunami wave resulted in a large amount of house destruction. Awareness must be raised as part of short term activities to avoid construction waste from being indiscriminately disposed of in landfills.

⁷ Logistical difficulties have been encountered in the transportation and transfer of small bulldozers required for clean up operations.

- (iv) The program should also consider the immediate formulation of a strategy/logistic plan by MEC, in joint collaboration with MPND and MOAD, to optimize immediate waste management and disposal needs, such as would be the collection of a critical amount of recyclables for sale and recovery of costs, waste segregation by type and ultimate disposal of hazardous waste (eg destroyed asbestos roofing) debris from tsunami-resulting destruction;⁸
- (v) a comprehensive community awareness program to inform and train communities on the proposed program of intervention, including hygiene materials, hygiene promotion/education, environmental solid waste management as well as community organization for effective support. The Hygiene Promotion Programme targeting schools children and communities should be re-initiated.⁹
- (vi) in addition, institutional development and support to the atolls administration through capacity building programs will be necessary to implement the above needs;

16. **Cost Estimates for Immediate and Short Term Assistance (3–6 months).** Cost estimates for the above activities are in Table 1. These are tentative and based on the 2004 available unit cost data. They include transportation costs and 10% annual price contingency. The estimated cost for immediate relief and short-term assistance is estimated to be MRf 234 million (\$ 18 million)

Table 1. Cost Estimates for Immediate and Short Term Assistance

Subcomponent	MRf ('000)	US \$ ('000)
Water supply	131,780	10,300
Sanitation	41,700	3,260
Solid Waste Management	33,740	2,640
Environmental Awareness and Education	6,400	500
Total	213,610	16,690
Contingency (10%)	21,360	1,670
Grand Total	234,970	18,360

17. **Donor Response and Financing of Immediate and Short Term Needs (3-6 months).** The Government has initiated discussions with various international agencies and NGOs, including UNICEF and ADB. Total contributions are still to be finalized but should include:

- (i) UNICEF has committed to providing (15+3) reverse osmosis boat-mounted units for desalination, whereas others, including Oxfam UK (3 units), Graham Tek Singapore (2 units) and THW and Kappel Engineers (4 units) have already committed up to 9 plants, 2 of which are large size.
- (ii) Various bilateral and private sector donations amount at present to over 100,000L of packaged drinking water.
- (iii) The Norwegian Government has at present committed to providing 50 -1000L collapsible storage containers whilst the German Government proposes to provide 8

⁸ The program should focus on (i) developing infrastructure for the disposal of different waste components separately, (ii) maximizing the opportunity for local processing and re-use of materials, including the introduction of composting (iii) maximizing the opportunity for local income generation, through transshipment of segregated and baled metals, glass, plastics and other recyclable materials to a central facility, (iv) maximizing opportunities for community-based approach to solid waste collection and disposal practice, (v) maximizing the opportunities for better household waste management practices and the use of planned collection and disposal facilities, (vi) using the community's potential for operation and maintenance.

⁹ Particular attention is to strengthen people's knowledge, attitudes and day-to-day practices for adoption of safe hygiene practices. Findings from assessments have indicated that thousands of people are under threats of diseases due to damaged water & sanitation facilities, crowded conditions for displaced people and seawater contamination. The MoH with assistance from UNICEF and in collaboration with Ministry of Education and WHO is developing a hygiene promotion campaign which will focus on key hygiene behaviour to reduce health risks for the population.

- water purification units for production of drinking units, laboratory equipment and pumps.
- (iv) Oxfam will be providing a selection of water equipment, including 4-11m³ tanks and 3-10m³ ground bladder PVC tanks. The International Federation of the Red Cross and Red Crescent will be providing 2-10 m³ ground water bladders,
 - (v) UNICEF has also proposed the supply of 60 individual garbage bins with covers (large), 60 garbage bins with covers (small) and 60 dustbins opening 2 way, as well as 2 conductivity meters.

18. **Medium-Term to Long-Term Assistance (Up to 2-3 years).** This phase, covering a period of up to 2-3 years should focus on providing a comprehensive sanitation and solid waste management program both to help improve the standard of living of island-affected communities and prevent further marine and terrestrial contamination. The sector strategy will need to provide for

- (i) rehabilitation and reconstruction of environmental infrastructure damaged by the tsunami¹⁰;
- (ii) upgrading and development of sewage treatment and disposal facilities in islands where rebuilding or potential relocation is required and population is sufficiently large as to ensure the scheme's sustainability;
- (iii) introduction and development of solid waste management systems, including formalization of solid waste management centers and solid waste management capacity building programs including promotion of composite from biodegradable materials to support community/household composting of solid waste and sewage sludge for tsunami-damaged soil enrichment;
- (iv) community mobilization and organization for utilities management, operation and maintenance;
- (v) institutional strengthening and capacity building for environmental management, including:
 - a. development of environmental awareness programs for island communities;
 - b. formulation and piloting of environmental (water testing, pollutant migration, geohydrological studies) monitoring programs;
 - c. institutionalizing land use planning as a necessary tool in environmental management;

19. Natural and water resources in islands where displaced communities are being hosted are at risk of overextraction and additional polluting pressures. These have been addressed through the provision of additional rainwater tanks (600), under the assumption that population density allows to accommodate families in individual plots. In addition, the design of a suitable hygiene and sanitation program including sewage treatment prior to disposal for these selected islands with critical population levels has been incorporated in the development plans for island expansion, to preserve the environmental absorptive capacity of the islands. Long term recovery of the water lens needs to be monitored through a purpose-design monitoring program and comparison with exiting pre-tsunami base-line from wells and 20 boreholes in North and South Regions and Malé.¹¹ Aquifer recharge practices such as those incorporated in the design of road drainage mechanisms will have to be further promoted in reconstruction activities.

20. The overall sanitation strategy and choice of technical options considers the suitability of locally adapted technology, affordability and financial sustainability considerations, institutional arrangements

¹⁰ This shall ensure the continuation of programs such as school water and sanitation programs, such as UNICEF WES program.

¹¹ As part of the needs assessment, the provision of 2 water testing systems per affected atoll and associated consumables has been incorporated.

and cultural factors. Selection of adequate sanitation infrastructure covering tsunami most affected islands, should include:

- (i) Rehabilitation and replacement of damaged sanitation infrastructure (up to 5000 toilets and 1600 septic tanks) in households and communal buildings;
- (ii) Construction of permanent septic and hygienic sludge drying beds (a total of 69 units will be required, based on population needs on substantially to very highly affected islands);
- (iii) Repair or replacing of damaged small bore sewer and sea outfall, where damaged, and in selected cases, introduction of sewerage network systems in islands solely relying on a septic tanks/soak pit systems (up to 21 systems to be provided in total);¹²
- (iv) Introduction of cost effective septage treatment facilities, particularly in islands with both high population levels and high population densities, as may result from the Government proposed ‘safe-island’ programs and potential relocation needs.¹³ For this purpose, further testing and MWSA piloting efforts for the identification of adequate and adapted systems such as reed bed systems should be further promoted;
- (v) Preparation of a sanitation and water strategy addressing increasing population in proposed safe islands, which shall include treatment and management options for optimization of resources and environmental sustainability.

21. Solid waste management facilities in the atolls should be formalized as solid waste management centers, where relief equipment is to be secured in adequately designed deposition bays, providing safe and properly laid electricity and water services, provision of concrete pads and leachate containment (expected to be minimal where waste is to be stored for short periods of time) and enclosing of light waste by means of fencing. Means for safe disposal of hazardous waste debris, especially asbestos which was commonly used in construction and roofing, must be separately addressed.¹⁴ In addition, replacement of clinical waste small-size incinerators has been considered for atoll and regional hospitals in highly affected islands (3 in total).

Table 2. Cost Estimates for Medium Term Assistance

Subcomponent	MRf (‘000)	US \$ (‘000)
Water supply	21,280	1,660
Sanitation *	255,880	19,950
Solid Waste Management	18,880	1,470
Environmental Monitoring and Environmental Awareness Programs	21,250	1,600
Total	317,010	24,730
Contingency (10%)	31,710	2,470
Grand Total	348,810	27,210

* Considers introduction of sewage treatment systems and basic reed-bed sewage treatment facilities for 15 highly affected islands with critical population level.

VI. Long Term Development Needs

22. Although beyond the objectives of a tsunami-damage and needs assessment, development needs identified to be urgently required in the Maldives include (i) provision of safe drinking water to

¹² Coverage has been addressed taking into account the sustainability of these schemes when new systems are to be constructed, and this has been related to population size.

¹³ It is expected that septic tanks for up to 30% of the affected population may be required (6000 new septic tanks), and upgrading of systems to include full sewerage systems, reed bed treatment and outfall to see through raiser mains for up to 15 islands.

¹⁴ Provision for this has been included under the Environmental Section.

individuals subject to shortages, (ii) provision of acceptable sanitation and sewage treatment options throughout the country, including Malé, which shall be coupled with the introduction of user fees, (iii) a long-term solid waste management approach for the Maldives needs to review available acceptable options for the disposal of non-recyclables and hazardous waste. As part of the formulation of a countrywide long-term waste management strategy, GOM must consider collection and treatment of non-recyclables and hazardous waste in a centralized small-scale incineration facility (one which should be located in the vicinity of Malé) or the provision of an environmentally safe sanitary landfill site(-s) comprising a section fulfilling hazardous waste specifications, in key islands such as Regional Development Centers. The latter should include the much needed lining and upgrading of Thilafushi central landfill site.

V. Next Steps

23. A detailed assessment of reconstruction needs for the various affected islands will have to be undertaken, this will partly determine how to prioritize activities, both in a geographic and sectoral context.

24. In addition, Government policies and strategies in selected subsectors, currently under preparation or review, will need to be confirmed.